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EP-A-0 012 258
GB-A-2 054 840
GB-A-2 068 044
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Descripti n

This invention relates to mechanical vibration absorbing restraint means which are used in nuclear safety systems. In particular, the vibration restraint means according to this invention is usable with generally cylindrical out-of-core nuclear radiation detectors which must be mechanically supported in a vertical position about a nuclear reactor vessel. This invention restrains the motion of a radiation detector during a seismic event and substantially absorbs vibration forces induced thereby which would otherwise be transmitted to the internal mechanism of the detector.

The typical out-of-core radiation detector utilized in nuclear safety systems is an ion chamber of substantial length, for example about 6 to 12 feet (1.83 to 3.66 m) long. The ion chamber typically utilizes concentric cylindrical electrodes which are maintained a fixed distance apart, with opposed electrical potentials for attracting respectively the oppositely charged particles which are generated in the ion chamber by neutrons from the reactor core. Such ion chambers are thus used to monitor reactor activity and to indicate the operational status of the reactor. The ion chamber is typically mounted in an elongated tubular thimble which is typically open ended at the top and may be closed or open ended at the bottom. A plurality of such thimbles are spaced around the reactor vessel in a predetermined array to permit sampling of the neutron flux level in the vicinity of the reactor vessel. Seismic activity can result in the ion chamber striking the thimble wall generating significant forces which cause electrical noise to be present in the output signal from such ion chambers. This electrical noise is thought to be a result of the vibratory motion of the electrodes relative to each other in the ion chamber.

The tubular thimbles within which the ion chamber radiation detectors are typically mounted can have a variable inside diameter, as is typical for commercially available piping which is used in forming the reactor thimbles. A typical 6 inch (15.28 cm) nominal diameter schedule 80 piping typically will have an inside diameter which ranges from about 5.931 inch (15.065 cm) to 5.622 inch (14.28 cm), and 6 inch (15.24 cm) nominal diameter schedule 40 pipe has a resultant inside diameter range of from about 6.197 inch (15.74 cm) to 5.964 inch (15.149 cm). With such inside diameter range variations of up to about 0.2 inch (5.08 mm) inside diameter, it is difficult to provide a detector support means which provides a uniform fit and support of the detector assembly for the wide range of thimble inside diameters. It has thus been necessary to provide a rather loose fit in current detector support assemblies relative to the thimble ID. This leads to high levels of acceleration and deceleration of the detector assembly during seismic activity and results in undesirable electrical signals generated by motion of the internal detector parts. The presently utilized detector support assemblies are also rigid assemblies and there is thus no damping of impact shocks experienced by the assembly during seismic activity.

Additionally, the qualification of neutron detectors for use in the thimble requires that the detectors be capable of operating before, during and after a seismic event. Seismic event test sequences have been developed to conservatively simulate the seismic conditions predicted for a reactor. The capability of the neutron detector to survive the seismic test depends upon the energy absorption characteristics of the detector structure and the amount of energy transmitted to that structure. Internal damage to the detector mechanism and/or excessive and noisy signal outputs can result if either the detector or its support structure are unable to dissipate the seismic energy.

An example of a vibration absorbing restraint device is disclosed in US Patent Application Serial No. 382437 filed May 26, 1982. The restraint device utilizes spring bias means to mount a radiation detector in a tubular thimble.

Reference is made to GB—A—2054840 in which there is disclosed a restraint means for supporting a generally cylindrical nuclear radiation detector within a tubular thimble, which restraint means comprises two housing segments having a spring associated therewith for attaching one said housing segment to another said housing segment in order to form a clamp-like ring which is securably connectable about the detector, the spring being operably associated with and extending from each of said housing segments for generally radial displacement relative to said detector such that the tubular thimble is contacted thereby.

It is an object of this invention to provide a vibration absorbing restraint means capable of absorbing and dissipating a significant fraction of the seismic energy that the detector can receive during a seismic event, either actual or simulated and can reduce electrical noise.

It is another object of the present invention to provide a vibration absorbing restraint means which maintains electrical isolation between the detector and the inside wall of the thimble.

It is also an object of this invention to provide a vibration absorbing restraint means which provides support for a detector assembly within a tubular thimble where the range of thimble inside diameters has significant variation.

Accordingly, the present invention resides in a vibration absorbing restraint means for supporting a generally cylindrical nuclear radiation detector within a tubular thimble, wherein said restraint means comprises: at least two housing segments having interconnecting means associated therewith for attaching one said housing segment to another said housing segment in order to form a clamp-like ring which is securably connectable about the generally cylindrical detector, and at least one energy absorbing means operably associated with and extending from

each of said housing segments for generally radial displacement relative to said detector such that the tubular thimble is contacted thereby, characterised in that each energy absorbing means includes a thimble contacting means and a motion damping means disposed between the thimble contacting means and one of the housing segments. Desirably, the thimble contacting means is electrically non-conductive and the damping means is characterized by resiliency and a lack of resonance.

In order that the invention can be more clearly understood, a preferred embodiment thereof will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is a side elevational view of an elongated out-of-core radiation detector mounted by means of a vibration absorbing means within a tubular thimble with portions of the thimble cut away;

Figure 2 is an enlarged view taken along the line II—II of Figure 1 illustrating in plan the restraint means; and

Figure 3 is a cross sectional, side elevational view of a segment of the restraint means segment illustrating an energy absorbing means.

Referring to Figure 1, an elongated vertically disposed tubular thimble 11, is one of a plurality of such thimbles which are disposed about a nuclear reactor vessel within the containment building of a nuclear power plant. The thimble 11 is typically a 6 or 7 inch (15.24 or 17.78 cm) nominal diameter schedule 40 or schedule 80 pipe, which is open at the upper end, and may be closed or open at the bottom end. An elongated, generally cylindrical nuclear radiation detector 13 is mounted within the thimble 11 in a generally coaxial relationship therewith. The radiation detector 13 is typically of the ion chamber type which has an outside diameter of about 3 inches (7.62 cm) and ranges from approximately one foot (30.48 cm) to about 12 feet (3.66 m) long. Electrical leads 15 extend from one end of the radiation detector 13 and are in communication with a remotely located control system which provides operating input potential and an output signal measuring means. The radiation detector 13 generates an output signal which is indicative of nuetron flux passing through the detector.

A plurality of vibration absorbing restraint means, generally indicated by the reference characters 17a and 17b, are longitudinally spaced along the length of the cylindrical radiation detector 13 and are securely connected thereto to provide a support means for the detector 13 within the thimble 11. The seismic restraint means 17a and 17b are identical in structure. One such restraint means 17a is best seen in detail in Figures 2 and 3.

The restraint means 17a comprises a plurality of housing segments 19a, 19b, 19c, 19d and 19e, each having an arcuate interior surface 21 with a radius of curvature slightly larger than the generally cylindrical radiation detector 13. The individual housing segments 19a through 19e are brought together about the detector 13, with a plurality of fastening means generally indicated by the reference character 23, securely connecting the plurality of housing segments to the detector 13. The fastening means 23 each comprise a bolt 25 passing through an aperture 27 in each of a contiguous pair of housing segments. The bolt 25 is secured by a lock nut 29 and provided with washers 31. Alternatively, the housing segments can be secured together by a fastening means which comprises a bolt passing through an aperture in a first housing segment and engaging a threaded aperture in a second housing segment. In such an alternative arrangement, each housing segment is provided with a pair of apertures, one of which is threaded to securely receive a bolt therein. When the plurality of housing segments are fastened together, they define a generally circular seismic restraint means 17a about the cylindrical detector 13. The preferably circular perimeter 33 of the seismic restraint means 17a has a slightly smaller diameter than the inside diameter 35 of the thimble 11.

A housing segment 19a of the restraint means 17a is best understood through consideration of Figures 2 and 3. The housing segment 19a includes a means generally indicated at 37 for absorbing energy generated by a seismic event. The energy is absorbed in a nonlinear manner as a function of displacement of the means 37, thus providing high energy dissipation within the restraint structure. An example of a force versus displacement function for a device according to this invention is:

$$F=ax^b$$

where F is the applied force, x is the displacement of the bearing surface with respect to its original position and a and b are constants that depend on the structure of the restraint. One of the significant factors resulting from this equation is that the force versus displacement function is non-linear such that large displacements produce several times the restraining force that small displacements produce.

The energy absorbing means 37 of a segment 19a is shown in cross-sectional, side elevational view in Figure 3 and includes a thimble contact means and damping means. A thimble contact means, preferably ceramic insulator 41, is mounted on a plunger member 43 by means of a securing means 45 which is recessed as at 47. The ceramic insulator 41 provides electrical insulation between the radiation detector 13 and the thimble 11. The plunger member 43 is preferably circular in cross section and slidably disposed within a pad well or bore 49 in the housing segment 19a. The plunger member 43 is removably retained in the bore 49 by means of a C-shaped retaining ring 51 placed in a circumferentially disposed slot 53 in the inside surface 55 of the pad well 49. Plunger motion within the pad well 49 is restrained by a

damping means 57 consisting of a resilient material which is non-resonant. One such damping means is a knitted metal pad 57 disposed between the bottom of the plunger member 43 and the bottom of the pad well 49. The knitted metal pad 57 is preferably formed metal, mesh tubing that has been flattened and then wound to form a disk-like pad with an outside diameter slightly smaller than the inside diameter of the pad well 49. The ends 59 of the pad 57 can be welded to maintain the wound form thereof as shown. The pad 57 need not be and preferably is not, wound tightly, but rather the mesh tubing is wound to form a pad 57 with an annular center opening 59. A metal, mesh tubing which is well suited for use in the formation of a damping means is described in U.S. Patent 4,340,210, Pile Driver Cushion, by P. Townsend.

Various other pad constructions may also be used, examples of which include stainless steel wool and a thin metal strip looped to form a sponge-like structure. The previously described force versus deflection function produced by the pad 57 is controlled by the characteristics of the material from which the pad is formed. Herein the wire size and wire mesh size together with the forming force used in flattening and winding the tubing into a pad are controlling.

During a seismic event, the ceramic insulator 41 contacts the thimble structure. As the ceramic insulator and plunger compress the pad 57, a portion of the kinetic energy that would normally be imparted to the radiation detector 13 is instead absorbed by the pad 57. The pad 57 is overdamped and as a result, does not immediately spring back to the original position. The energy absorbing means 37 according to this invention does not contribute to the detector the type of vibrational movement that is typically generated in prior seismic restraint devices. Because seismic motion is random, there is a finite probability that the energy absorbing means 37 will be subjected to a second and possibly a third blow before it recovers from the first event. The result will be shorter displacement before the motion of the plunger is restrained, with a slightly greater force being transmitted to the detector for each successive event. Contrary to prior device, the present energy absorbing means 37 does not experience any resonance point in the 1 hertz to 100 hertz range in which the pad 57 will effectively cease to provide restraint.

The energy absorbing means 37 can be adapted to fit various sizes of thimbles or instrument wells through the use of one or more spacing shims 51 placed between the plunger 43 and the ceramic insulator 41.

While a seismic restraint means consisting of five segments with a single energy absorbing means in each segment has been shown, a variety of configurations are possible. For example, the seismic restraint means might comprise two segments with two or three energy absorbing means therein or three segments with at least one energy absorbing means in each segment.

What has been described is a vibration absorbing means with improved energy absorbing characteristics.

Claims

1. A vibration absorbing restraint means for supporting a generally cylindrical nuclear radiation detector within a tubular thimble (11) said restraint means comprises: at least two housing segments (19) having interconnecting means (23, 25, 29) associated therewith for attaching one said housing segment to another said housing segment in order to form a clamp-like ring (17) which is securably connectable about the generally cylindrical detector (13), and at least one energy absorbing means (37) operably associated with and extending from each of said housing segments (19) for generally radial displacement relative to said detector (13) such that the tubular thimble (11) is contacted thereby, characterized in that the energy-absorbing means (37) includes a thimble-contacting means (41) and a motion-damping means (57) disposed between one of the housing segments and said thimble contacting means (41).

2. A vibration absorbing restraint means according to claim 1 characterized in that the thimble-contacting means (41) consist of an electrically non-conductive material and provides electrical insulation between the thimble (11) and the detector (13).

3. A vibration absorbing restraint means according to claim 1 or 2, characterized in that the motion-damping means (57) is a resilient material which is non-resonant.

4. A vibration absorbing restraint means according to claim 3, characterized in that the damping means (57) is a knitted metal pad formed from wound, flattened mesh tubing.

5. A vibration absorbing restraint means according to claim 3, characterized in that the damping means (57) is a stainless steel wool.

6. A vibration absorbing restraint means according to claim 4, characterized in that the damping means (57) is a thin metal strip looped to form a sponge-like structure.

7. A vibration absorbing restraint means according to any of claims 2 to 5, characterized in that the energy absorbing means (37) includes a plunger means onto which the thimble contacting means (41) is mounted and the housing segment has a radially aligned bore (59) therein adapted to receive the damping means (57) and the plunger means (43), therein such that the radial displacement of the energy absorbing means (37) is effected through the compression and expansion of the damping means (57) in said bore.

8. A vibration absorbing restraint means according to claim 7, characterized in that the thimble contacting means (41) is removably secured to the plunger means (43) and the energy absorbing means includes (37) at least one spacing shim (51) disposed therebetween.

9. A vibration absorbing restraint means accord-

ing to any of claims 1 to 8, characterized in that each of the housing segments (19) includes three energy absorbing means (37) operably associated therewith.

10. A vibration absorbing restraint means according to any of the preceding claims, characterized in that the restraint means comprises five housing segments (19a—e) and an energy absorbing means (37) operably associated with each said housing segment.

Patentansprüche

1. Eine vibrationsabsorbierende Rückhalteeinrichtung für die Stützung eines im wesentlichen zylindrischen Kernstrahlungsdetektors innerhalb eines rohrförmigen Rohres (11), wobei die Rückhalteeinrichtung folgendes umfaßt: Zumindestens zwei Gehäusesegmente (19), mit denen Verbindungseinrichtungen (23, 25, 29) verknüpft sind, um eines der Gehäusesegmente mit einem anderen derartigen Gehäusesegment zu verbinden, um einen klammerartigen Ring (17) zu bilden, der um den im wesentlichen zylindrischen Detektor (13) sichernd verbindbar ist, und zumindest eine Energie absorbierende Einrichtung (37), die mit jedem der Gehäusesegmente (19) wirksam verknüpft ist und sich von diesem erstreckt zur im wesentlichen radialen Verschiebung relativ zu dem Detektor (13), so daß das rohrförmige Rohr (11) dadurch kontaktiert wird, dadurch gekennzeichnet, daß die energieabsorbierende Einrichtung (37) eine Rohrkontaktierungseinrichtung (41) und eine bewegungsdämpfende Einrichtung (57) umfassen, die zwischen einem der Gehäusesegmente und der Rohrkontaktierungseinrichtung (41) angeordnet ist.

2. Eine vibrationsabsorbierende Rückhalteeinrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Rohrkontaktierungseinrichtung (41) aus einem elektrisch nicht leitendem Material besteht und eine elektrische Isolierung zwischen dem Rohr (11) und dem Detektor (13) liefert.

3. Eine vibrationsabsorbierende Rückhalteeinrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die bewegungsdämpfende Einrichtung (57) ein nachgiebiges Material ist, das nichtresonant ist.

4. Eine vibrationsabsorbierende Rückhalteeinrichtung nach Anspruch 3, dadurch gekennzeichnet, daß die dämpfende Einrichtung (57) ein geknüpftes Metallkissen ist, das aus gewundenem, abgeflachtem Geweberohr geformt ist.

5. Eine vibrationsabsorbierende Rückhalteeinrichtung nach Anspruch 3, dadurch gekennzeichnet, daß die Dämpfende Einrichtung (57) eine rostfreie Stahlwolle ist.

6. Eine vibrationsabsorbierende Rückhalteeinrichtung nach Anspruch 4, dadurch gekennzeichnet, daß die dämpfende Einrichtung (57) ein dünner Metallstreifen ist, der zur Bildung einer schwammartigen Struktur gewunden ist.

7. Eine vibrationsabsorbierende Rückhalteeinrichtung nach einem der Ansprüche 2 bis 5, dadurch gekennzeichnet, daß die energieabsorbierende Einrichtung (37) eine Kolbeneinrichtung umfaßt, auf die die Rohrkontaktierungseinrichtung (41) montiert ist, und daß das Gehäusesegment eine radial ausgerichtete Bohrung (59) darin aufweist, angepasst, um die dämpfende Einrichtungen (57) und die Kolbeneinrichtung (43) darin aufzunehmen, so daß die radiale Verschiebung der energieabsorbierenden Einrichtung (37) bewirkt wird durch die Kompression und Expansion der dämpfenden Einrichtung (57) in der Bohrung.

8. Eine vibrationsabsorbierende Rückhalteeinrichtung nach Anspruch 7, dadurch gekennzeichnet, daß die Rohrkontaktierungseinrichtung (41) entfernbar an der Kolbeneinrichtung (43) befestigt ist, und daß die energieabsorbierende Einrichtung (37) zumindest eine Abstand gebende Beilagscheibe (51) dazwischen angeordnet umfassen.

9. Eine vibrationsabsorbierende Rückhalteeinrichtung nach einem der Ansprüche 1 bis 8, dadurch gekennzeichnet, daß jedes der Gehäusesegmente (19) drei energieabsorbierende Einrichtungen (37) umfassen, die damit wirksam verknüpft sind.

10. Eine vibrationsabsorbierende Rückhalteeinrichtung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Rückhalteeinrichtung fünft Gehäusesegmente (19a—e) und eine energieabsorbierende Einrichtung (37) umfassen, die mit jedem der Gehäusesegmente wirksam verknüpft ist.

Revendications

1. Dispositif de limitation et d'absorption de vibrations destiné à supporter un détecteur de rayonnement nucléaire généralement cylindrique à l'intérieur d'une bague tubulaire (11), ce dispositif de limitation comprenant: au moins deux segments de carter (19) munis de moyens de liaison (23, 25, 29) associés à ceux-ci pour fixer un segment de carter à un autre segment de carter de manière à former un anneau en forme d'anneau de blocage (17) pouvant être fixé autour du détecteur généralement cylindrique (13), et au moins un dispositif d'absorption d'énergie (37) associé en fonctionnement à chaque segment de carter (19) et partant de celui-ci pour effectuer un déplacement généralement radial par rapport au détecteur (13) de manière à venir ainsi en contact avec la bague tubulaire (11), ce dispositif de limitation et d'absorption de vibrations caractérisé en ce que le dispositif d'absorption d'énergie (37) comprend un dispositif (41) venant en contact avec sa bague, et un dispositif d'amortissement de mouvement (57) placé entre l'un des segments de carter et le dispositif (41) venant en contact avec la bague.

2. Dispositif de limitation et d'absorption de vibrations selon la revendication 1, caractérisé en ce que le dispositif (41) venant en contact avec la bague est constitué par un matériau électriquement non conducteur, de manière à assurer l'isolement électrique entre la bague (11) et le détecteur (13).

3. Dispositif de limitation et d'absorption de

vibrations selon l'une quelconque des revendications 1 et 2, caractérisé en ce que le dispositif d'amortissement de mouvement (57) est constitué par un matériau élastique non résonnant.

4. Dispositif de limitation et d'absorption de vibrations selon la revendication 3, caractérisé en ce que le dispositif d'amortissement (57) est constitué par un tampon de métal tressé formé d'une tube maillé enroulé et aplati.

5. Dispositif de limitation et d'absorption de vibrations selon la revendication 3, caractérisé en ce que le dispositif d'amortissement (57) est constitué par de la laine d'acier inoxydable.

6. Dispositif de limitation et d'absorption de vibrations selon la revendication 4, caractérisé en ce que le dispositif d'amortissement (57) est constitué par une bande métallique mince enroulée en boucle pour former une structure spongieuse.

7. Dispositif de limitation et d'absorption de vibrations selon l'une quelconque des revendications 2 à 5, caractérisé en ce que le dispositif d'absorption d'énergie (37) comprend un dispositif de plongeur sur lequel est monté le dispositif (41) venant en contact avec la bague, et en ce que le segment de carter contient un trou radialement aligné (59) destiné à recevoir le dispositif d'amortissement (57) et le dispositif de plongeur (43) de façon que le déplacement radial du dispositif d'absorption d'énergie (37) s'effectue par compression et dilatation du dispositif d'amortissement (57) dans ce trou.

8. Dispositif de limitation et d'absorption de vibrations selon la revendication 7, caractérisé en ce que le dispositif (41) venant en contact avec la bague est fixé de manière amovible au dispositif de plongeur (43), et en ce que le dispositif d'absorption d'énergie (37) comprend au moins une cale d'espacement (51) disposée entre les deux.

9. Dispositif de limitation et d'absorption de vibrations selon l'une quelconque des revendications 1 à 8, caractérisé en ce que chacun des segments de carter (19) comprend trois dispositifs d'absorption d'énergie (37) associée opérationnellement à celui-ci.

10. Dispositif de limitation et d'absorption de vibrations selon l'une quelconque des revendications 1 à 9, caractérisé en ce que le dispositif de limitation comprend cinq segments de carter (19a à e) et un dispositif d'absorption d'énergie (37) associé opérationnellement à chacun de ces segments de carter.

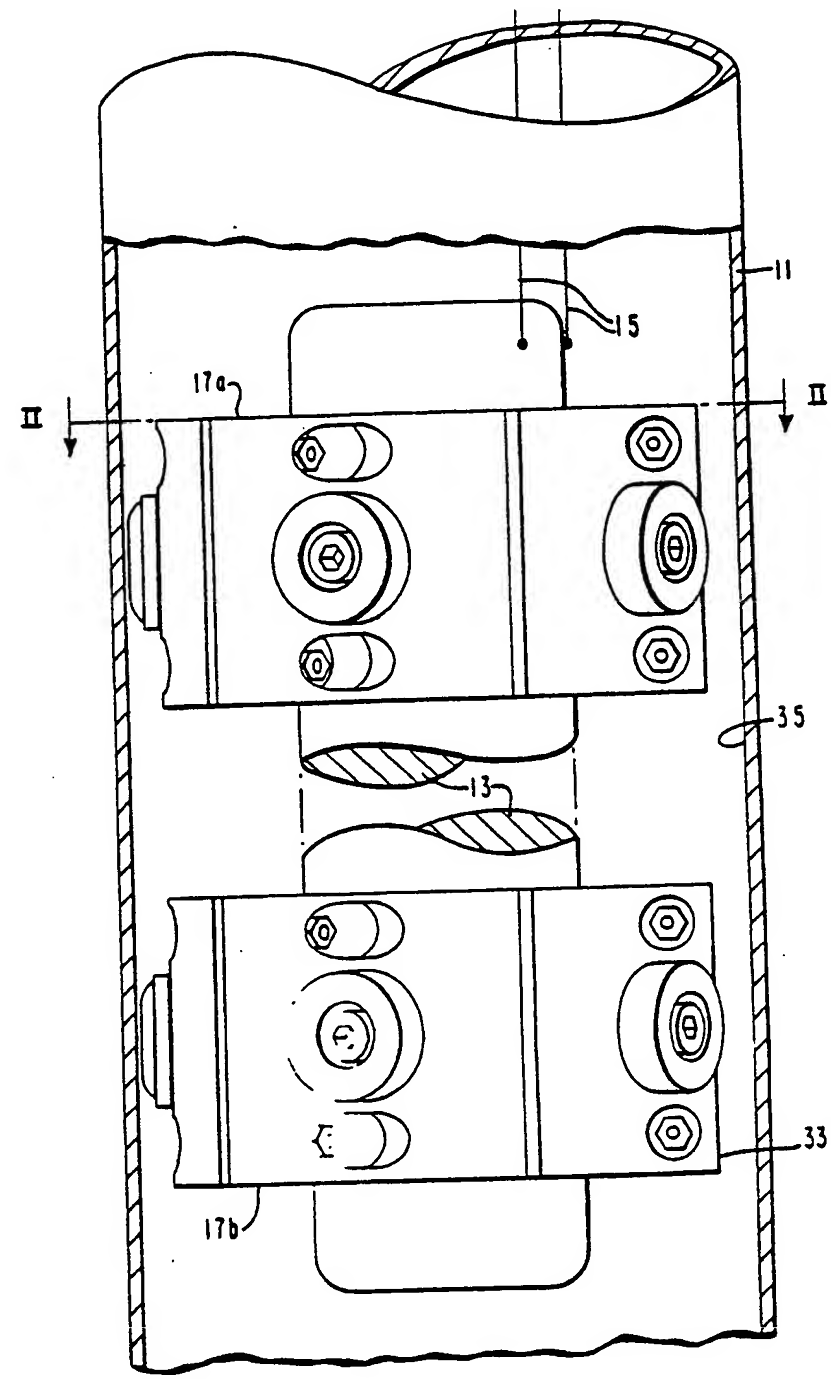
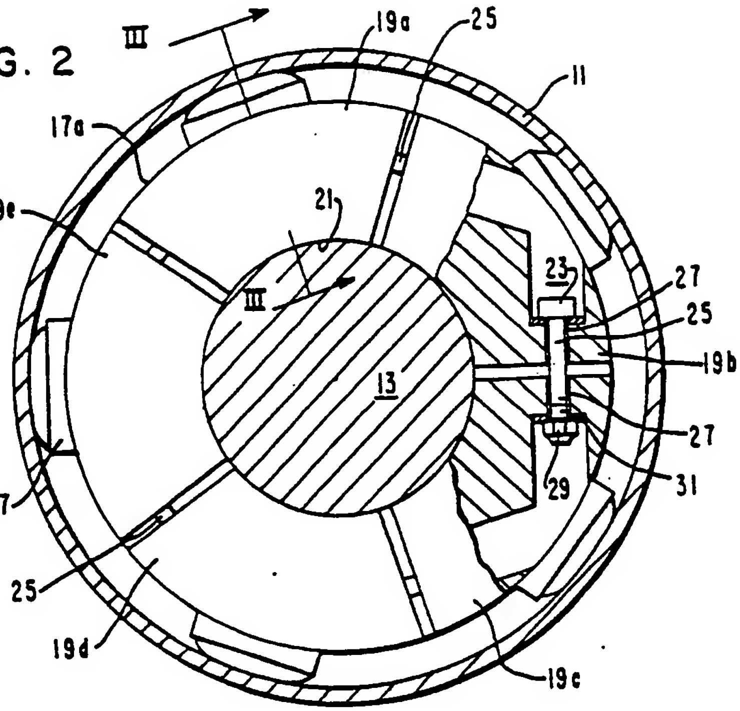


FIG. 1

FIG. 2


III
19a
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11
17a
19e
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III
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27
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19b
13
27
29
31
37
25
19d
19c

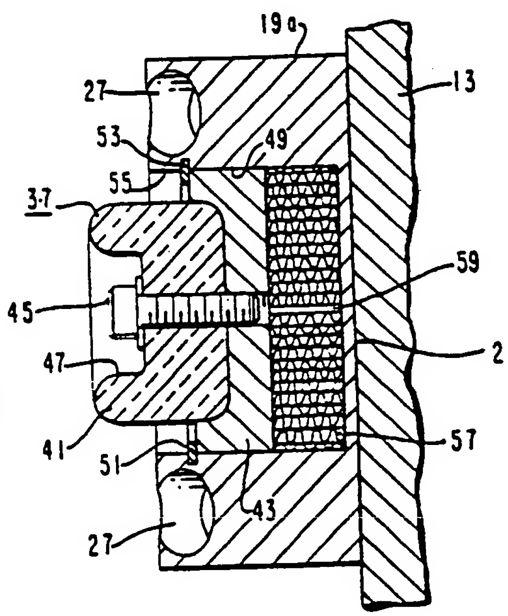
19a
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FIG. 3